LLNL Environmental Restoration Division Standard Operating Procedure	TITLE: Well Installation
APPROVAL Date _____ _____ Livermore Site Deputy Program Leader	PREPARERS: J. Gardner*, S. Gregory, J. Hoffman*, and S. Nelson* REVIEWERS: R. Bainer, L. Berg*, T. Carlsen, V. Dibley, and J. Greci
APPROVAL Date _____ _____ Division Leader CONCURRENCE Date _____ _____ QA Implementation Coordinator	PROCEDURE NUMBER: ERD SOP-1.4 REVISION: 2 EFFECTIVE DATE: December 1, 1995 Page 1 of 14

***Weiss Associates**

1.0 PURPOSE

To ensure proper well design and installation**.** Wells provide a means of collecting representative ground water samples and water-level data from a distinct water-bearing zone. Wells can also be used to extract contaminated ground water, or reinject treated ground water.

2.0 APPLICABILITY

This procedure is applicable for all personnel performing well installation operations, and shall be fully reviewed prior to conducting these activities.

3.0 REFERENCES

3.1 Department of Water Resources (1981), *Water Well Standards*: *State of California*, California Resources Agency, Bulletin 74-81.

3.2 Driscoll, F. G. (1986), *Ground Water and Wells*, Johnson Division, St. Paul, Minnesota.

3.3 U. S. Environmental Protection Agency (1987), *A Compendium of Superfund Field Operations Methods*, EPA/540/p-87/001.

4.0 DEFINITIONS

4.1 Annulus

The space between the drill string or casing and the wall of the borehole.

4.2 Bridging

An obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the borehole, by the intrusion of a large boulder, or by filter pack materials during well completion.

4.3 Centralizer

A device used to keep the well casing centered within the borehole.

4.4 Hydrologic Unit

A group of one or more stratigraphic units that is considered a single hydraulic system.

4.5 Stratigraphic Unit

A discrete unit or section of sediment or rock identified primarily by material with similar characteristics.

4.6 Tremie Pipe

A section of small diameter pipe, usually composed of polyvinyl chloride (PVC) tubing, which is used when adding sand, bentonite, or grout into the annulus of the borehole around the well casing so the annulus is filled from the bottom up. This helps to prevent bridging.

4.7 Well Screen

The section of the completed well with small perforations in the casing that allows water to flow into the casing.

5.0 RESPONSIBILITIES

Note: The following responsibilities (Sections 5.1–5.5) are listed by the appropriate level of authority to ensure that proper representation for all procedures and regulations related to this SOP are met.

5.1 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Hydrogeologic Group Leader (HGL)

The HGL's responsibility is to ensure that proper procedures are followed for activities (i.e., drilling, borehole logging and sampling, monitor well installations and development) and to oversee the disposal of all investigation derived wastes.

5.3 Drilling Supervisor (DS)

The DS plans and coordinates all drilling related activities, ensures that all drilling related activities are performed safely and efficiently (using the proper procedures), and that the data generated from these activities are valuable and representative of the true geologic or physical conditions within the borehole. Such activities may include operation of logging equipment, soil sampling, well installation, and development. The DS is also responsible for:

5.3.1 Coordination of the drilling contractor schedules and equipment needs:

- Coordinate the schedules of multiple drill rigs with the drilling contractor.
- Provide the Work Plan to the drilling contractor and answer questions.
- Negotiate the arrival/start date and drill type.
- Monitor the progress of the drilling and anticipate changes in equipment needs (e.g., auger rig, air-mist rig, mud-rotary rig).

5.4 Drilling Coordinator (DC)

5.4.1 The DC provides the interface between the DS and the field activities including:

- Oversight of the Drilling Geologist (DG) and field activities.
- Coordinate the DG's work load.
- Obtain the necessary equipment, supplies, and release numbers from the Technical Release Representative (TRR) for the drilling contractor.
- Provide guidance and training.
- Inform the DG about procedural changes in areas related to drilling (e.g., changes in sampling requests, cuttings disposal issues, new forms, etc.).
- Provide technical input to the DG and Study Area Leader (SAL)/Facility Task Leader (FTL).
- Review borehole and geophysical logs.
- Monitor drilling progress on a daily basis.
- Interact with the Quality Assurance (QA)/Quality Control (QC) officer on drilling and soil sampling issues.
- Estimate the contaminants likely to be present, and the quantity of drilling spoils that may be generated.

5.4.2 During the startup of a new drilling phase, the DS works with the DC and SAL/FTL to:

- Create and finalize all related drilling documents (i.e., the Work Plan and Sampling Plan).
- Work with the SAL/FTL to establish drilling locations, schedules, and budgets for each well.
- Determine the protective equipment necessary for personnel in the field.
- Make well completion decisions and specify the well construction details from the SAL/FTL and Hydrogeologic Group Leader (HGL) input.
- Act as the liaison between the SAL/FTL and the DG.
- Coordinates all necessary biological/archeological surveys prior to drilling. Results of the surveys should be forwarded to the SAL/FTL and Environmental Chemistry and Biological Group Leader (ECBGL).

5.5 Drilling Geologist (DG)

The DG's responsibility is to ensure that drilling activities are carried out according to the specifications designated in the Work Plan, Sampling Plan, Site Safety Plan (SSP), Operation Safety Procedure (OSP), and Standard Operating Procedure (SOP). Additionally, the DG must oversee and document all aspects of the drilling/field investigation, including lithologic and geophysical data, well completion and development specifications, activities of the drillers, sampling and workspace monitoring details. The DG is also responsible for:

5.5.1 Site Preparation and Supply Ordering. The DG must:

- Review the Work Plan prepared by the SAL/FTL and DC, and discuss any questions.
- Assemble all necessary materials, including personal protective equipment (PPE).
- Supply tracking and ordering requests.
- Confirm that all necessary security arrangements have been made to permit site access (e.g., schedule escorts, notify the building coordinator of planned activities, arrange for opening of locked gates).
- Confirm that utility locator and mud pit excavations (if necessary) have been arranged with the field personnel.
- Discuss LLNL site planning requirements and utility lines with field personnel and drillers before drilling begins.

5.5.2 Site Safety

- Supply the SSP, OSP, and SOPs to all workers who enter the drill site.
- Monitor and record work space conditions with appropriate monitoring equipment (including FID, PID, etc.) during drilling activity.
- Confirm that appropriate fencing, warning signs, barricades, animal exit ramps (for mud pit), borehole cover and protection are in place.
- Discontinue work and contact the DC if chemical or physical hazards are encountered.

5.5.3 Field Activities

- Coordinate schedules/actions with field personnel.
- Research site hydrogeology to estimate key parameters (e.g., sample target zones, hydrostratigraphic unit depths and thicknesses, and types of contaminants).
- Obtain a field logbook from the Data Management Group (DMG).
- Calibrate and record calibration information for all monitoring equipment.
- Confirm all sample naming conventions with DMG.
- Collect and document samples.
- Handle all changes and corrections to chain-of-custody (CoC) forms and/or analytical requests.
- Inform the DC, SAL/FTLs, and DMG of any sampling or sampling documentation irregularities.
- Report any deviations from the SSPs, OSPs, or SOPs to the QA/QC Officer.
- If SOPs are violated, a nonconformance report is to be completed and submitted to the QA/QC officer.
- Report missed turnaround times for analytical sample results to QA/QC Officer.
- Confirm that drilling waste analytical results are consistent with the chosen disposal method.
- Decontaminate all sampling equipment.
- Provide frequent updates and documentation of field activities to the DC, HGL, and SAL/FTL.

5.6 Environmental Chemistry and Biology Group Leader (ECBGL)

The ECBGL's responsibility is to provide biological or chemical information and expertise (i.e., biological surveys, water supplies, chemical field instruments, etc.).

5.7 Field Personnel

The field personnel's responsibilities are to conduct all ERD field work that complies with all established operational and safety procedures, and to inform the HGL when the procedures are inappropriate.

Activities the field personnel are responsible to perform (but are not limited to) are to:

- Collect, store, and ship borehole samples to analytical laboratories.
- Drill, complete wells, log boreholes, and properly develop wells to allow the highest yield and the highest quality samples.
- Communicate the performance of development activities to the HGL and DC to allow for modification of the development methods to improve well yield.

5.8 Site Safety Officer (SSO)

The SSO's responsibility is to ensure the safety of ERD's ongoing operations and facilities and work performed. The SSO's responsibility is to receive the details of potential hazards and procedures for all field activities. The SSO directs this information to the LLNL Hazards Control Department to determine if a new Operational Safety Procedure (OSP) is required, thus assuring that an existing OSP addresses all ES&H issues for each operation.

5.9 Study Area Leaders (SAL)/Facility Task Leader (FTL)

The SAL/FTL are responsible for the overall investigation, planning, assessment, and remediation within a study area.

5.10 Technical Release Representative (TRR)

The TRR is responsible for the acquisition and administration of blanket contract releases for the procurement of goods and services. The TRR has the authority to obligate LLNL for payment of goods and services, delegated by the LLNL Business Manager through the LLNL Procurement Department.

5.11 Treatment Facility Hydrogeologist (TFH)

The TFH is responsible for helping the FTL determine borehole location and target zone for completion.

6.0 PROCEDURES

Well installations create permanent access for collecting ground water samples, measuring aquifer characteristics, and extracting ground water or reinjecting treated water. Wells should only minimally alter the medium being sampled.

6.1 Office Preparation

6.1.1 Research site geology and hydrogeology (e.g., anticipated depth and thickness of water-bearing zones and confining layers, materials comprising water-bearing zones, contaminant type and concentration).

6.1.2 Review associated SOPs and pertinent sections of the SSP.

6.1.3 Obtain necessary items listed in the Equipment Checklist (Attachment A) and obtain appropriate personal protective equipment (PPE) for site activities per SOP 4.1, "General Instructions for Field Personnel."

6.2 Field Preparation

6.2.1 The source(s) of any water to be introduced into the borehole or wells must be approved by the ECBGL prior to field operations.

6.2.2 Decontaminate all equipment and well casing, screen, centralizers, etc. prior to monitor well installation per SOP 4.5, "General Equipment Decontamination."

6.2.3 Follow instructions pertaining to conducting field work per SOP 4.1.

6.3 Operation

6.3.1 No foreign materials can be introduced into the borehole without the DS's approval. Use of solvents, glues, oil, or cleaners in the borehole is prohibited. Mud stabilization additives may be allowed in certain situations. The DS may grant such approval after obtaining approval from the appropriate regulatory agencies.

6.3.2 Record the details of well installation on the Borehole/Well Construction Log, and document the depth from surface grade of the following: bottom of the boring, overdrill seal, screen, filter pack, bentonite seal, grout, cave-in (slough), centralizers and conductor casing, if permanent. Record the composition of the grout, seals, and filter pack on each Borehole/Well Construction Log. Document the casing/screen material and casing/screen inside diameter; document the screen slot size and the wellhead completion. At the end of the Borehole/Well Construction Log, indicate the type and amount of supplies used for well construction.

6.3.3 In all cases, the minimum physical protection worn should consist of hard hat, safety glasses, hearing protection, and steel-toed boots. Additional safety equipment may be specified by the SSO or Hazards Control.

6.3.4 Use Schedule 40 PVC casing with 0.020-in. screen slot size for wells installed exclusively as monitor wells unless instructed otherwise by the DS. If the well is installed to perform as an injection, extraction, or production well, the DS, in concert with the DC, DG, and SAL/FTL, will determine the filter pack and screen slot size based on lithologic descriptions on the Borehole/Well Construction Log as per SOP 1.1, interpretation of geophysical logs as performed per SOP 1.6, and if available, sieve analyses of the lithology in the screened interval. In addition, these personnel will determine the casing material (generally Schedule 40 or Schedule 80 PVC, stainless steel, or low carbon steel) based on site-specific conditions such as water quality, installation objectives, required tensile and compressive strengths, and the required life expectancy of the well.

6.3.5 Use plastic centralizers on all well installations unless the casing is being installed through hollow-stem augers. Fasten centralizers to the well casing by mechanical fasteners radially spaced about the casing at 120 or 90° degrees. Install centralizers at the top and bottom of the screened casing, and install at least one other on the blank casing at intervals not greater than 40 ft (Attachment B). Provide a description of the centralizer fastening device and the locations on the Borehole/Well Construction Log.

6.3.6 Drill all boreholes at least 4 in. greater in diameter than the outer diameter of the casing to be installed (minimum required work space in annulus is 2 in.). When setting a conductor casing, it is preferable to complete the casing a foot or more into the underlying clay or other fine-grained unit, if present.

6.3.7 Place a filter pack in the annulus adjacent to the well screen in all monitor wells. The filter pack limits the transmission of sand and fines from the formation to the well, and stabilizes the formation. The filter pack should not extend within 5 ft of any water-bearing zone other than the one to be monitored. Well design should

be modified to allow for a sufficient filter pack without threat of interconnecting water-bearing zones.

A. Fill the annulus between the well screen and borehole wall with washed Lonestar Lapis Luster #3 Monterey-type sand (or an equivalent 8 × 20 U.S. standard sieve size or filter pack approved by the DS) extending a minimum of 1 ft above the screen. A cap should be placed over the top of the well casing before pouring the sand down the annulus to prevent sand from entering the casing.

B. When determined by the DS or designee, the filter pack is emplaced using a tremie pipe. For this, install a sand slurry composed of sand and potable water through the tremie pipe into the annulus throughout the entire screened interval and over the top of the screen. Continuously tag the depth of the filter pack to ensure that bridging does not occur.

C. It is necessary to place sufficient filter material to fully cover the screen after the sand has settled. Install at least 2 ft of sand above the top of a 5- to 10-ft-long screen. Increase the minimum filter pack thickness by approximately 1 ft for each additional 10 ft of screen. Cover the #3 sand with a minimum 1-ft layer of finer-grained Lonestar Olympia concrete sand #0 (or equivalent). The #0 sand is not added until it is verified that the #3 sand extends above the screen as discussed above. Attachment B displays a typical installation using the #0 sand.

D. Ascertain the depth of the top of the sand using a weighted tape or tremie pipe recorded by the DG.

6.3.8 Place a bentonite seal between the filter pack and grout to prevent infiltration of cement into the filter pack and the well. The bentonite should not be added until it is determined that there has been no settling of the filter pack. Compact the filter pack by making a few passes with a bailer prior to the installation of the bentonite seal. The steps below discuss the use of bentonite. Attachment B displays a typical installation using bentonite. A fine sand (#0) may be used on top of the bentonite seal if conditions warrant as determined by the driller and DG and approved by the DS.

A. Fill the annulus between well casing and borehole with a bentonite seal at least 2 ft thick (vertically) in the interval between the fine sand above the filter pack and the grout seal. Bentonite seal thickness may be increased to an extra foot of bentonite seal for each additional 50 ft of depth for deep wells (200 ft or more).

B. Use bentonite pellets with a minimum purity of 90% sodium montmorillonite (with no additives) and a minimum dry bulk density of 75 lb/cu ft for 1/2-in. pellets. Place a cap over the top of the well casing and slowly pour the bentonite pellets directly down the annulus. Pour the pellets from different points around the casing to ensure even distribution in the annulus. Test the borehole for bridging of the bentonite during application. Bentonite chips may be used to reduce bridging problems and costs. Add enough approved clean water, usually 10 to 20 gal, to completely hydrate the bentonite.

C. Tag the top of the bentonite seal with a tremie pipe or a weighted tape to verify that the proper thickness of seal has been placed in the annulus.

D. Leave the bentonite pellets undisturbed to hydrate and expand for a minimum of 45 min prior to placing grout. Bentonite chips should be allowed 1.5 hr to hydrate prior to placing grout.

6.3.9 Place grout from the top of the bentonite seal to the surface. Only Type I/II [American Society for Testing and Materials (ASTM C-150)] cement without accelerator additives may be used, unless otherwise specified by the DS. Place the grout in the monitor wells as follows:

A. Completely fill the annulus between the well casing and borehole wall.

B. Place the grout with a tremie pipe unless the borehole is dry and does not exceed a depth of 30 ft. The tremie pipe typically used is 1.25-in. PVC. The tremie pipe must have a "J" tube on the lower end.

C. Pump the grout through this pipe to the bottom of the open annulus until undiluted grout flows from the annulus at the ground surface. Deeper annular depths and larger diameter boreholes may require large amounts of grout. In these cases, set grout in 100 to 150-gal lifts, allowing sufficient time for the grout mix to set between lifts. Use approved accelerators such as Cal-Seal, to decrease setting times. Certain subsurface/borehole conditions may require an initial small lift of grout (<15 ft) to prevent rupturing the bentonite seal. The DG should check with the DC, SAL/FTL, and DS on each completion.

D. The grout should consist of a neat cement mix composed of 2 lb of commercial bentonite powder and approximately 6.5 gal of water added per 94-lb bag of cement. Only grout mixed with approved water should be used.

E. After the grout has set (about 72 h), fill any depression in the grout due to settlement with a grout mix similar to that described above.

6.3.10 Install a protective stove pipe or a below-grade vault around all monitor wells. This will normally be done at a later date by LLNL technicians. Prior to installation, the DG should ensure temporary wellhead protection by placing barriers around the well. The minimum elements in the protection design should include:

A. Protective stove pipe (above grade).

1. Install a minimum 2 ft × 2 ft, 3-ft-thick concrete pad, such that surface drainage is diverted away from the wellhead.

2. Secure a metal stovepipe to the concrete pad. The stovepipe must keep precipitation out of the monitor well and is secured by a padlock. The exact height of the stove pipe is recorded and reported to the Data Management Group (DMG) and Sampling Coordinator (SC), as appropriate.

3. Place the well identification label on the protective casing.

B. Vault (installed below grade when wells are located in streets, parking lots, or sidewalks).

1. Install the vault so that surface drainage is diverted away from the vault.

2. The lid of the vault must keep fluids out of the vault and have a key locking system.

3. Install a traffic-rated vault for installations in streets or parking lots.

6.4 Field Post Operation

6.4.1 Due to failure to reach specified depths, loss of tools, inadvertent contamination, or any other cause approved by the DS, the well or borehole should be abandoned as discussed in SOP 1.7, "Well Closures."

6.4.2 Decontaminate all the equipment as noted in SOP 4.5.

6.4.3 Return the site to its original condition, using best reasonable efforts, and notify the DC that the well is completed and is ready for surveying and pump installation.

6.4.4 Arrange to have the LLNL Survey Team survey the cement pad or the edge of the vault to the nearest 0.01 ft. A shiny, metal well identification tag (shiner) is attached to the survey location (concrete pad or edge of vault) by the Survey Team with the well ID stamped on the tag. A copy of the survey data is distributed to the DC, DMG, and SC.

6.5 Office Post Operation

6.5.1 Give original field forms to the DC for review.

6.5.2 A copy of the Borehole/Well Construction Log as well as all other supporting well documentation shall be distributed upon completion of initial development to all appropriate personnel including the DMG and SC.

7.0 QUALITY ASSURANCE RECORDS

7.1 Borehole/Well Construction Log

7.2 Document Control Logbook

8.0 ATTACHMENTS

Attachment A—Equipment Checklist

Attachment B—Typical Monitor Well

Attachment A

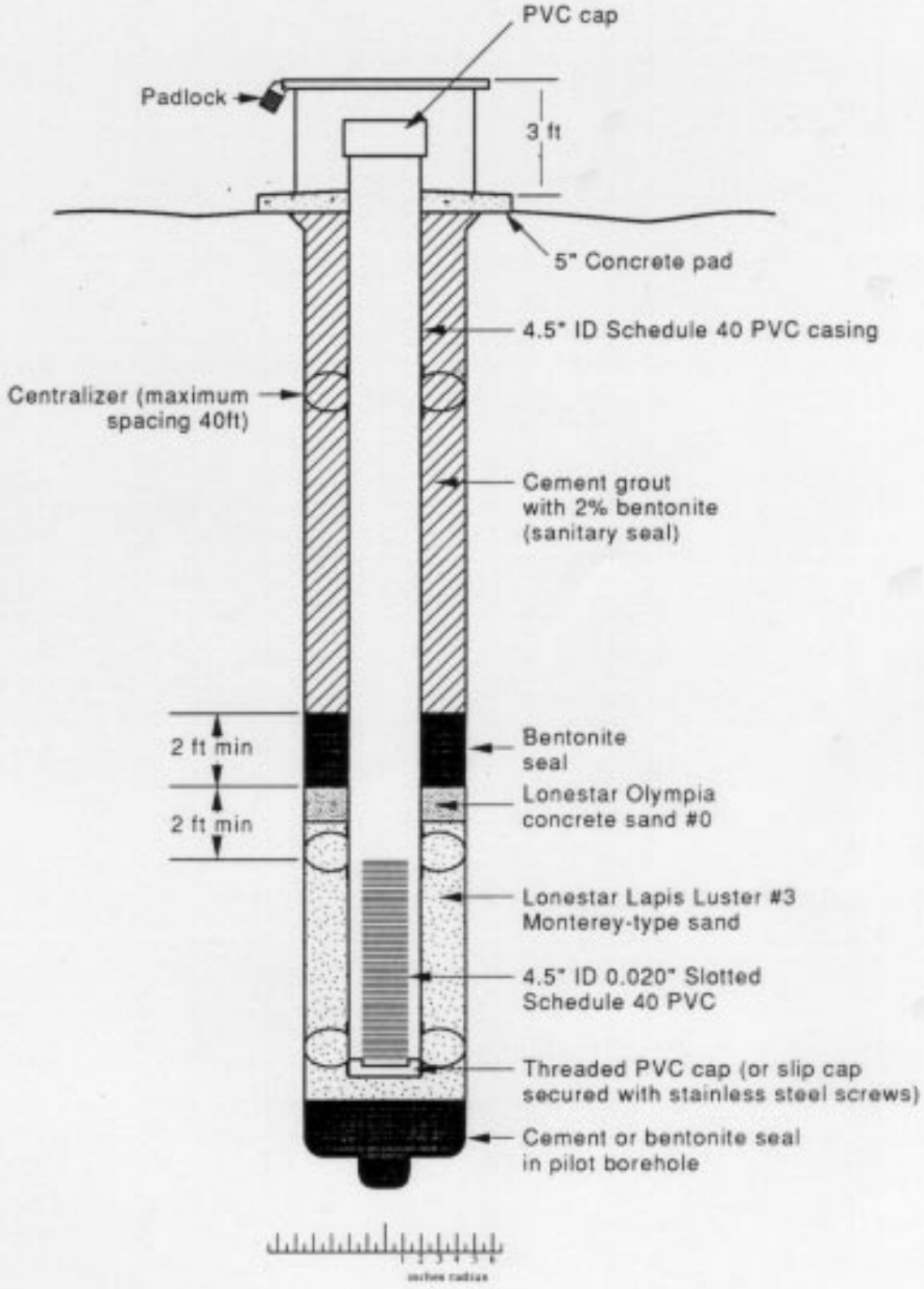
Equipment Checklist

Equipment Checklist

____ Any applicable permits
____ Appropriate clothing (i.e., coveralls, steel-toed safety shoes, gloves)
____ Applicable documents (i.e., SSP, OSPs, SOPs, etc.)
____ Barricades
____ Buckets and brushes
____ Caution tape
____ Cooler with ice
____ Company ID sign for vehicle
____ Core boxes, marking pens
____ Deionized water
____ Detergents (Alconox, TSP)
____ Document control logbook
____ Field forms (i.e., borehole/well constructions form)
____ Field notebook
____ First aid kit
____ Fire extinguisher
____ Hard hat
____ Hearing protection
____ PID or FID
____ Rock hammer
____ Safety glasses
____ Sample containers/labels
____ Signs listing responsible persons
____ Steel measuring tape
____ Steel spatula
____ Water-level meter
____ 300-ft weighted tape

Attachment B

Typical Monitor Well



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SOP 1.4—Attachment B. Typical Monitor Well.